

Practical Methods to Seal and Insulate Residential Buildings

**Projects supported in part
by the Alberta/Canada
Energy Resources
Research Fund**



87-03363/

Cover Photo: Studies have shown that energy losses through air leaks and poor insulation can be substantially reduced by retrofitting multi-family dwellings (shown here) and other residential buildings typical of Alberta's housing stock.

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Pub. No. I/167

ISBN 0-86499-408-7

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Foreword

Since 1976, numerous projects have been initiated in Alberta by industry and by academic research institutions which are aimed at better utilization of Alberta's energy resources.

These research, development and demonstration efforts were funded by the Alberta/Canada Energy Resources Research Fund (A/CERRF), which was established as a result of the 1974 agreement on oil prices between the federal government and the producing provinces.

Responsibility for applying and administering the fund rests with the A/CERRF Committee, made up of senior Alberta and federal government officials.

A/CERRF program priorities have focused on coal, energy conservation and renewable energy and conventional energy resources. Administration for the program is provided by staff within the Scientific and Engineering Services and Research Division of Alberta Energy.

In order to make research results available to industry and others who can use the information, highlights of studies are reported in a series of technology transfer booklets. For more information about other publications in the series, please refer to page nine.

Practical Methods to Seal and Insulate Residential Buildings

In the field of building science, it is recognized that two mechanisms are primarily responsible for heat losses from any type of building.

The first is conduction of heat from the relatively warm building interior through the walls, doors and windows to the relatively colder exterior. This type of heat movement can be reduced by placing insulating materials in the walls or by using specially constructed windows and doors that are poor conductors of heat.

The second heat loss mechanism involves leakage of air through openings in the building envelope; for example, between a door and the door frame.

Although most new homes built today generally are insulated to levels that are twice what they were 10 years ago, there is a need for simple and inexpensive retrofit methods that can be used by homeowners to improve the level of insulation in older dwellings. Also, more investigations are needed to pinpoint methods of reducing air leakage in homes, particularly in multi-family dwellings which, until very recently, were not included in studies of residential energy consumption. For these reasons, three A/CERRF-funded studies were undertaken during 1983 to 1985 to provide some baseline information about air leakage and the insulation characteristics of Alberta homes and to demonstrate some practical methods of sealing and insulating dwellings typically found in Alberta.

A Survey of Air Leakage in Calgary Homes

During an investigation carried out by Bill Johnston Architect Ltd. of Calgary, 117 occupied homes in Calgary were tested to determine their airtightness characteristics and to pinpoint the most cost-effective methods that could be used to reduce heat loss due to air leaks.

The houses chosen for the investigation were thought to be a representative sample of Calgary's housing stock. Variables that were considered in making the selection included age, dwelling type, exterior finish, window type and area and the number of flues and vents.

The types of homes ranged from detached bungalows, bi-levels, split levels and two-storey units to semi-detached dwellings and rowhouses. They had been built during periods that ranged from before 1946 to some time after 1979.



Airtightness of homes was measured by depressurization fans inserted in door openings.

Study Approach

Each of the test homes was pressure-tested using the fan-door depressurization method to exhaust air from the structure and thus create a partial vacuum inside. This allowed air from the outside to infiltrate through openings in the building envelope and gave rise to measurements of the air change rate. This variable is defined as the number of times in one hour the heated volume of a building changes, at a standard pressure of 50 Pascals, due to air leaking through the building envelope.

Having established the baseline air change rates for typical Calgary homes, measurements were repeated after certain components of 30 homes were sealed, such as band-joists, window and door frames, light fixtures, exterior wall baseboard, windows, doors, attic hatches, plumbing stacks, chimney chases, ductwork and electrical outlets on exterior and interior walls.

Twenty homes were sealed by Home-Seal, a Calgary company specializing in home sealing, while 10 homes were sealed by homeowners. In the case of professionally sealed homes, air change rates were measured incrementally after each type of leak source was sealed. In this manner, those components which were largely responsible for air leakage could be identified.

This allowed the investigators to calculate retrofit costs, energy savings and payback periods and determine whether it made a difference if the retrofit work was done by homeowners or by a professional sealing company.

In order to obtain some measure of the impact of sealing on heat losses, natural gas consumption was monitored for one year after homes were sealed. This information was compared with gas consumption figures for the five-year period prior to sealing.

Results

Study results were published in April 1986 in a report entitled "A Survey of Air Leakage in Calgary Homes."

On average, the air change rate at 50 Pascals for the 117-home sample was 4.31 per hour, which indicates a reasonable degree of airtightness. Of the various housing types, bungalows had the lowest air change rates — 3.91 per hour — while, at 6.17, row houses had the highest. Under normal conditions, rather than the pressurization conditions used in this test, the air change rates of occupied homes would be approximately 1/12 the numbers reported here.

Effect of Sequential Sealing on Air Change

Component(s) Sealed	Reduction In AC50Pa
Band-Joist	0.25
Window/Door Frames, Attic Hatch, Light Fixtures	0.28
Exterior Baseboard	0.08
Window Gaskets	0.22
Door Weatherstripping	0.18
Plumbing Stacks, Chimney Chases	0.17
Wall Penetrations, Electrical Plugs & Switches	0.05
TOTAL	1.23

(Source: A Survey of Air Leakage in Calgary Homes. B. Johnston Architect Ltd., April 1986)

Not surprisingly, the oldest homes, those built before 1946, had high air change rates at 50 Pascals (10.15), while those built during the 1961-70 period had the lowest (3.47). Houses built during the 1960's outperformed newer homes primarily because the post-1979 sample included a higher proportion of row houses which, of all the building types tested, had the highest air change rates. Another factor favoring 1960's homes was the type of siding used on many of them, in this case stucco, which was found to be the least permeable to air movement.

Stucco's impermeability was matched by aluminum siding used on some newer homes. Houses using either type of siding had air change rates of 3.79 per hour, but homes with woodlap exteriors showed relatively high (5.26) air change rates

Although it was found that the total area of glass windows in any home had only a negligible effect on air change rates, window types had a significant effect. Homes with wooden double-hung windows had higher air change rates (6.07 per hour) than those using casement or awning windows (3.28 air changes per hour).

The number of chimneys, flues and vents that were present in a home was found to have little influence on air change rates.

Overall, the sealing work performed on 30 Calgary homes resulted in an average drop of 19 per cent in the air change rate. Homes sealed by owners achieved a 17 per cent decrease, while homes sealed by Home-Seal showed a 20 per cent drop.

The study showed that the greatest reduction in air leakage can be achieved by sealing window and door frames, attic hatches and around light fixtures. The least effective action is to place gaskets in electrical outlets.

When comparisons were made of fuel usage before and after sealing, it was found that sealing caused an average decrease in gas consumption of 14 per cent, accompanied by a 12 per cent drop in fuel costs.

Some important differences in payback periods were noted between homes sealed by owners and those sealed by the professional sealing company. The average payback for homeowner-sealed dwellings was only 2.6 years, whereas the payback for sealing work performed by professionals was six years.

The difference is due to the fact that homeowners do not assign any costs to their own labor, whereas professionals charge for wages and overhead in addition to materials.

This body of work provides useful guidance to homeowners who are contemplating some retrofit work on existing homes. Prospective home buyers can benefit from it, too, because it draws their attention to the relative importance of various dwelling components, such as siding and window types, to the overall energy-efficient characteristics of typical Alberta homes.

Townhouse Retrofit Demonstration Project

While the air leakage study by Johnston was underway, an A/CERRF-funded investigation was initiated by Love Energy Consultants of Calgary to provide some baseline energy conservation information for owners and occupants of townhouses. This is particularly relevant in today's housing marketplace because townhouses already account for 12 per cent of the existing housing stock in Calgary and are predicted to take a larger share of future residential housing, due to trends toward higher density housing developments. Furthermore, most practical demonstrations of residential energy conservation procedures up to 1983 involved detached single-family homes, but recent Alberta studies have shown that townhouses are a special case because they are susceptible to air leakage across the common, or party, walls that separate units from each other.

Because previous studies have shown that the magnitude of residential energy savings can be influenced strongly by the energy-consuming habits of occupants, Love Energy Consultants decided they would eliminate this factor in their study by choosing test townhouses that were unoccupied.

Study Approach

During the 1983/84 heating season, two townhouses underwent infra-red scans, depressurization testing, natural gas monitoring and a number of retrofit measures to determine the impact of such improvements as better insulation and air sealing on costs and energy consumption.

Natural gas consumption was measured daily and was corrected for degree days of heating to accommodate variations due to fluctuations in outdoor temperature. Once gas usage per degree day was calculated over a range of temperatures, gas consumption was extrapolated for a typical winter season.

Thermographic scans were made of both units to pinpoint heat loss locations. Thermography revealed some construction deficiencies such as missing insulation in a few locations and air penetration through gaps in vapor barriers. Air infiltration was also extensive along the attic portion of the party wall between units and around joists. Also, thermographic scans showed that combustion air ducts spilled large amounts of cold air into the basements of both units.

Following the initial analysis of the townhouse units, several components of each were sealed and insulated.

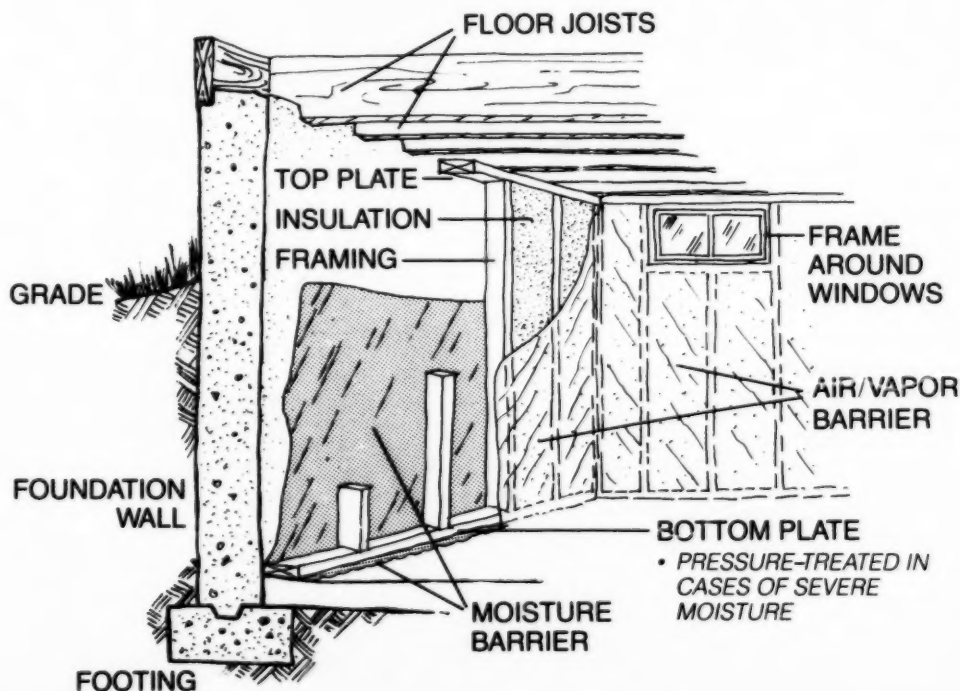
In one unit, caulking or weatherstripping was applied to window and door frames, the attic hatch and the front and back doors. Gaskets were inserted in the electrical outlets located on exterior walls. Unused vents, such as the dryer vent in the basement, were sealed.

In the second townhouse unit, basement walls were insulated by erecting an interior stud wall against the foundation to contain fibreglass batts. A polyethylene vapor barrier was then applied over the filled cavities.

Results

In the investigator's report, entitled "Townhouse Retrofit Demonstration Project: 1983-85," comparisons of thermographic scans that were made before and after the retrofit work showed a marked reduction in the number of air leak sources but energy savings, calculated from natural gas consumption records, amounted to only 8.5 or 8.8 per cent. This was lower than anticipated.

The payback period for the air-sealed unit was estimated to be two years, whereas the insulated unit would require a seven-year payback. In both instances, labor costs were not included because it was assumed the retrofit work could be performed by homeowners.



Interior basement wall insulation technique used in a townhouse retrofit.

(Illustration adapted from: *How to Insulate Your Basement, Interior Method*, Alberta Energy, Pub. No. 1/17-#3)

Because initial results were disappointing, the investigators received approval to extend their retrofit work to include "ideal" air sealing which comprised (1) placement of polyethylene vapor barriers over the windows of the air-sealed unit and (2) isolation of the furnace area from the remainder of the basement space in the insulated unit by erecting a polyethylene-covered stud wall around the furnace and water heater and then extending the combustion air duct so that it spilled air only into the isolated zone around the furnace.

After windows were sealed in the air-sealed unit, energy savings rose to 12 per cent. Isolation of the furnace in the second unit caused energy savings to jump to 21 per cent with a projected payback of two years.

Two additional units in a second townhouse complex were retrofitted and monitored during the 1984/85 heating season. Modifications were similar to those in the initial set of townhouses. Because thermographic scans and pressurization tests showed the second set of townhouses to be better constructed and subject to less air leakage than the first set, payback periods for all of the retrofits that were tried in these units exceeded five years for materials alone.

It was concluded that low-cost, air-sealing measures offered the most attractive paybacks, even though energy savings would likely be only about 10 per cent.

It was also noted that an examination of the natural gas consumption records for 24 occupied townhouses, in one of the complexes where test units were located, showed that the habits of occupants had a far greater impact on energy consumption than any of the physical modifications that were tried. For example, the highest energy consumers used 12 times as much natural gas as the lowest energy users.

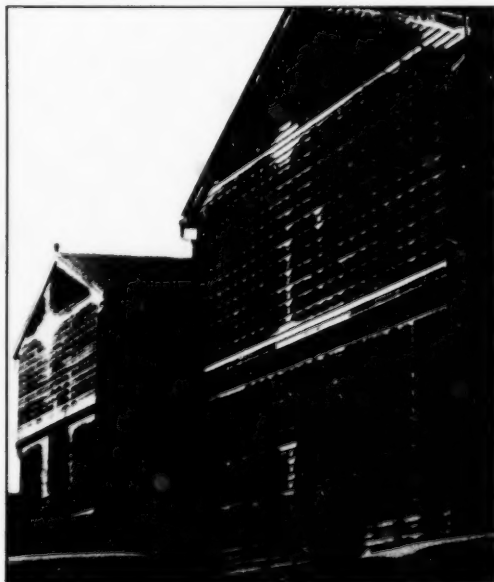
Self-Help Retrofit Manual for Owners of Multi-Family Housing Units

Twenty energy-conserving retrofit products, techniques and measures were analyzed by ARE — Alternative and Retrofit Energies Inc. of Calgary to determine their suitability in multi-family and detached homes. Nine were field-tested at Springhill Ranch Housing Co-op, a 43-unit townhouse development in northwest Calgary.

To be rated as cost effective, it was necessary that each device or concept be capable of a five-year payback period after installation or construction.

Of the field-tested items, the following were deemed to be cost effective:

1. interior air locks (vestibules) surrounding doors to minimize loss of heated air to the outside.
2. some available furnace interruptors, which are designed to interrupt the furnace combustion cycle to save fuel.
3. several types of air sealing.
4. window insulation kits comprising heat-shrink plastic film, which is taped to the inside window frames.



Under certain atmospheric conditions, condensation on the exterior surfaces of some types of buildings can reveal those locations where heat is lost through openings in the building envelope.

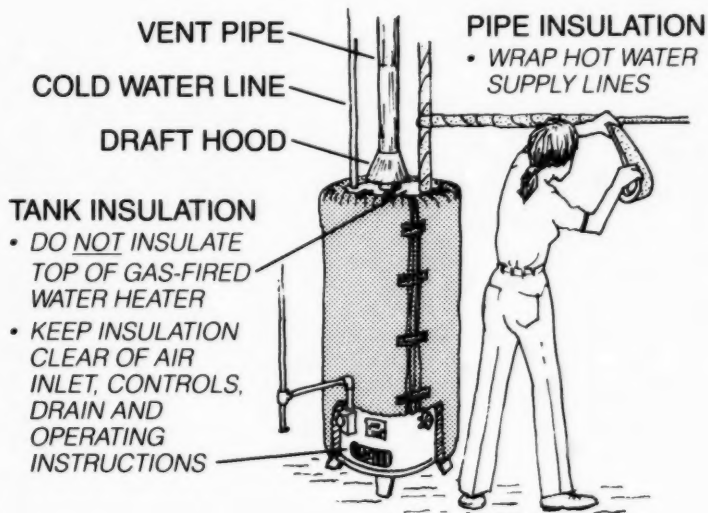
Other energy-saving techniques that were considered to be cost effective included:

- two methods of altering control of the combustion air supply to furnaces in air-tight homes
- basement wall insulation
- placing a used carpet on the basement floor
- sealing and insulating heating ducts
- using air insulation jackets on hot water tanks
- low flow shower heads
- hot water pipe insulation
- flow restrictors and aerators for faucets
- manual setback of furnace and hot water tank thermostats

For each energy-conserving technique assessed by the contractor, a separate section in the manual is devoted to its advantages and disadvantages, summaries of previous studies and detailed information regarding the installation/construction and operation of the item.

Also, several optional leak-locating techniques and devices were discussed. Similarly, various types of setback thermostats were reviewed and evaluated.

In addition to reporting payback periods for individual devices and techniques, and their impact on energy consumption, the contractor also noted that 10 to 32 per cent of all the energy consumed in the townhouse complex could be saved if residents simply changed their lifestyles.



An insulation jacket wrapped around a hot water tank is one energy-saving measure that can be cost effective

(Illustration adapted from: *Your Home Heating System*, Alberta Energy, Pub. No. 117-#5)

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